Non-CO_2 Greenhouse Gases: High-GWP Gases

Source/Sectors: Semiconductor Sector

Technology: CVD cleaning emission reduction/NF_3 remote clean (C.3.1)

Description of the Technology:
The Novellus's *In-situ* NF_3 Clean Technology system introduces NF_3 directly into the CVD process chamber where the gas is dissociated in plasma. NF_3 possesses a high GWP very close to that of C_2F_6, however, the chemical's overall high efficiency leads to the reduction of gas emissions and thus, less climate impact as compared to C_2F_6 (US Climate Change, 2005).

The NF_3 Remote Clean™ Technology developed by Applied Materials uses an upstream (remote) device to dissociate NF_3 using argon gas at a 99% efficiency rate. In addition, chamber cleaning times are 30 to 50% faster than baseline C_2F_6 clean times. The system converts the source gas to active N and F atoms in the plasma, upstream of the process chamber. These electrically neutral atoms can selectively remove material in the chamber. The remote cleaning technology differs from *in situ* technology in that the NF_3 dissociates into plasma before entering the chamber rather than being dissociated inside the chamber. The byproducts of Remote Clean™ include HF, F_2, and other gases, of which all but F_2 are removed by facility acid scrubber systems (US Climate Change, 2005).

Effectiveness: Good

Implementability: All fabrication facilities

Reliability: Good

Maturity: Good.

Environmental Benefits: High-GWP gas emission reduction

Cost Effectiveness:

Technology	Lifetime (yrs)	MP (%)	RE (%)	TA (%)	Capital cost	Annual cost	Benefits
CVD cleaning emission reduction – NF_3 remote clean[1]	5	90	90	60	$90.76	$0.00	$0.00

Note: MP: market penetration; RE: reduction efficiency; TA: technical applicability; costs are in year 2000 US$/$MT_{CO2\text{-}Eq.}$

1: CEC (2005) & USEPA (2001)

Industry Acceptance Level: NF_3 use is rapidly gaining market share in the semiconductor industry for CVD chamber cleaning because of its high process efficiency.

Limitations: This option is only applicable to control emissions from chamber cleaning processes; it accounts for approximately 70% of total fabrication emissions (IEA, 2003).

Sources of Information:

1. Applied Materials (1999) "Catalytic Abatement of PFC Emissions", *Proc. Semicon Southwest 99 – A Partnership for PFC Emission Reduction*, October 18, Austin, Texas.

2. California Energy Commission (2005) “Emission Reduction Opportunities for Non-CO_2 Greenhouse Gases in California”, a report prepared by ICF Consulting for California Energy Commissions, CEC-500-2005-121, July 2005.

3. California Energy Commission (2006) “Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004”, final staff report, December 22, 2006.

4. Ecofys (1999) “Reduction of the Emissions of HFCs, PFCs and SF_6 in the European Union”, Commissioned by DG XI of the European Commission, authored by H. Heijnes, M. van Brummelen, and K. Blok, April 1999.

5. Intergovernmental Panel on Climate Change - IPCC (2001) “Summary for Policy Makers: A Report of Working Group I of the Intergovernmental Panel on Climate Change”, The Third Assessment Report - Working Group I, January 2001.

6. International Energy Agency (2001) “Abatement of Emissions of Other Greenhouse Gases - Engineered Chemicals”, Report Number PH3/35, IEA Greenhouse Gas R&D Programme, Cheltenham, United Kingdom, February 2001.

7. International Energy Agency (2003) “Building the Cost Curves for the Industrial Sources of Non-CO_2 Greenhouse Gases”, Report Number PH4/25, IEA Greenhouse Gas R&D Programme, Cheltenham, United Kingdom, October 2003.

8. International SEMATECH (1999) “Motorola Evaluation of the Applied Science and Technology, Inc. (ASTex) ASTRON Technology for perfluorocarbons (PFC) Emissions Reductions on the Applied Materials DxL Chemical Vapor Deposition (CVD) Chamber” Presented at: A Partnership for PFC Emissions Reductions, Semicon Southwest 99, Austin, Texas, October 1999.

9. McFarland, M.; van Gerwen, R. (2000) “Fluorine Compounds: Emissions Inventories, Options for Control and Their Implementation and Resulting Scenarios” in Non-CO_2 Greenhouse Gases: Scientific Understanding, Control and Implementation (edited by J. Van Ham *et al.*), Kluwer Academic Publishers, London.

10. Motorola (1999) “Long-term Evaluation of Litmus “Blue” Inductively-Coupled Plasma Device for Point-of-Use PFC and HFC Abatement”, *Proc. Semicon Southwest 99 – A Partnership for PFC Emission Reduction*, October 18, Austin, Texas.

11. Öko-Recherche (1999) “Emissions and Reduction Potentials of Hydrofluorocarbons, Perfluorocarbons and Sulphur Hexafluoride in Germany”, A study commissioned by the German Environmental Protection Agency, Germany, October 1999.

12. U.S. Climate Technology Program (2005) “Technology Options for the Near and Long Term”, U.S. Department of Energy, http://www.climatetechnology.gov/index.htm, August 2005.

13. U.S. Environmental Protection Agency (2001) “U.S. High GWP Gas Emissions 1990 – 2010: Inventories, Projections, and Opportunities”, Office of Air and Radiation, U.S. Environmental Protection Agency, EPA 000-F-97-000, June 2001.

14. U.S. Environmental Protection Agency (2006a) “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2004” Office of Atmospheric Programs, United States Environmental Protection Agency, EPA-430-R-06-002, June 2006

15. U.S. Environmental Protection Agency (2006b) “Global Mitigation of Non-CO_2 Greenhouse Gases”, Office of Atmospheric Programs, United States Environmental Protection Agency, EPA-430-R-06-005, June 2006.